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Mortality in South Asians and Caucasians After Percutaneous Coronary Intervention in the United Kingdom

An Observational Cohort Study of 279,256 Patients From the BCIS (British Cardiovascular Intervention Society) National Database

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Objectives The purpose of this study was to compare baseline characteristics and medium-term prognosis in South Asian and Caucasian patients undergoing percutaneous coronary intervention (PCI).

Background It is unclear whether South Asians undergoing PCI have worse outcomes than Caucasians.

Methods We performed a retrospective analysis of 279,256 patients undergoing PCI from 2004 to 2011 from the British Cardiovascular Intervention Society national database, of whom 259,318 (92.9%) were Caucasian and 19,938 (7.1%) were South Asian (South Asian includes patients of Pakistani, Indian, Bangladeshi, or Sri Lankan ethnic origin). The main outcome measures were in-hospital major adverse cardiac and cerebrovascular events and all-cause mortality during a median follow-up of 2.8 years (interquartile range: 1.5 to 4.5 years).

Results South Asians were younger (59.69 $\pm$ 0.27 years vs. 64.69 $\pm$ 0.13 years, $p > 0.0001$); more burdened by cardiovascular risk factors, particularly diabetes mellitus (42.1 $\pm$ 1.2% vs. 15.4 $\pm$ 0.4%, $p > 0.0001$); and more likely to have multivessel coronary disease than Caucasians. In-hospital rates of major adverse cardiac and cerebrovascular events were similar for South Asians and Caucasians (3.5% vs. 2.8%, $p = 0.40$). Unadjusted Kaplan-Meier estimates of all-cause mortality showed better survival for South Asians compared with Caucasians, after PCI for either acute myocardial infarction or angina. Age-adjusted analysis revealed increased mortality (hazard ratio: 1.24; 95% confidence interval: 1.18 to 1.30), but after adjustment for the substantial variation in baseline risk factors including diabetes, there was no significant difference between South Asians and Caucasians (hazard ratio: 0.99; 95% confidence interval: 0.94 to 1.05).

Conclusions In this large, contemporary cohort of patients treated by PCI, South Asians were younger but had more extensive disease and major risk factors, particularly diabetes. However, after correcting for these differences, in-hospital and medium-term mortality of South Asians was no worse than that of Caucasians. This suggests that in South Asians, the high prevalence of diabetes exerts an adverse influence on mortality, but ethnicity itself is not an independent predictor of outcome. (J Am Coll Cardiol Intv 2014;7:362–71) © 2014 by the American College of Cardiology Foundation

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Coronary artery disease (CAD) is more prevalent and presents earlier in South Asians than other ethnic groups (1,2), and this is associated with high rates of cardiovascular mortality (1,2). This is observed both in migrant South Asian populations and in South Asians who continue to reside in their homeland (2,3). Uncertainty exists about the explanation for this higher coronary mortality in South Asians—whether it is because of increased disease prevalence, increased case fatality, or a combination of the 2 factors. CAD appears to be more aggressive in patients of South Asian descent because it presents earlier and with more extensive angiographic disease (4). The observed accelerated CAD in South Asians can be explained predominantly by an excess of traditional risk factors, particularly type 2 diabetes mellitus, which cluster in South Asians (5), although other biological hypotheses have been proposed (6–8). Despite these risk factors, it is not clear whether South Asians diagnosed with CAD fare worse than Caucasians once they are treated.

Early registries reported that South Asians had higher cardiovascular mortality after acute myocardial infarction (AMI) than Caucasians (3,9,10). However, more contemporary registry data have suggested that this may not be the case, reporting similar or better short- and long-term survival after AMI in South Asians and Caucasians (11–13). It is also unclear whether South Asians undergoing percutaneous coronary intervention (PCI) have worse outcomes than Caucasians. The registry data detailing ethnic difference in outcomes after PCI for stable CAD are conflicting. Although some studies have suggested that after PCI, both South Asians and Caucasians have similar short- and long-term mortality, others have found higher post-procedural adverse event rates in South Asians (13–15). The small size and short follow-up period of these studies prevent firm conclusions from being drawn.

A single-center study suggested that all-cause mortality after PCI was no different in South Asians than in Caucasians, regardless of whether PCI was performed for stable angina or after AMI (11). However, this study reported outcomes from an urban community with a relatively high deprivation index (16). Whether this single-center cohort is representative of the U.K. South Asian population as a whole is uncertain. We therefore undertook a study using BCIS (British Cardiovascular Intervention Society) data, which are collected under the auspices of the NICOR (National Institute for Cardiovascular Outcomes Research), to examine the characteristics and outcomes of South Asian and Caucasian patients undergoing PCI for stable angina and acute coronary syndrome (ACS) in England and Wales, United Kingdom. In addition to describing the baseline characteristics of patients undergoing PCI, we were interested in describing and understanding the factors that might affect the outcome of South Asians after PCI. We were particularly interested to see whether any difference in outcome could be explained by conventional risk factors.

Methods

This was a retrospective, observational cohort study of 279,256 patients to investigate the relationship between South Asian ethnicity and outcome after PCI in England and Wales. We used the national database of the BCIS, which collects mandatory data from all PCI centers in the United Kingdom.

BCIS-NICOR database. The BCIS–NICOR database (17) collects data from all hospitals in the United Kingdom that perform PCI and records information about every procedure performed. PCI is defined as the use of any coronary device to approach, probe, or cross ≥1 coronary lesions with the intention of performing a coronary intervention. The database is part of the suite of datasets collected under the auspices of the NICOR (http://www.ucl.ac.uk/nicor) and is compliant with U.K. data protection legislation. Data are collected prospectively at each hospital, electronically encrypted, and transferred online to a central database where there is the facility for contemporary analysis and dissemination. Each patient entry offers details of the patient journey, including the method and timing of admission, inpatient investigations, results, treatment, and outcomes. For patients from England and Wales, patient survival data are obtained by linkage of patients' National Health Service (NHS) numbers to the Office of National Statistics, which records the date of death for all patients.

Study population. The study period was from January 2004 to July 2011. During this period, 474,078 patients underwent PCI in the United Kingdom, 413,988 of whom were from England and Wales, had NHS numbers, and comprised the initial population. Of these, 281,989 (68.1%) had ethnicity recorded and complete datasets and were included in the analysis. A total of 2,733 patients of black or Asian ethnicity, were not included. A total of 131,120 records (31.7%) did not have ethnicity documented, and this was the most common reason for exclusion from the study group. However, analysis of the outcomes of this excluded group was not significantly different from the study group (data not shown). The study

Abbreviations and Acronyms

ACS = acute coronary syndromes

AMI = acute myocardial infarction

BCIS = British Cardiovascular Intervention Society

CABG = coronary artery bypass grafting

CAD = coronary artery disease

CI = confidence interval

HR = hazard ratio

MACCE = major adverse cardiac and cerebrovascular event(s)

NHS = National Health Service

NICOR = National Institute for Cardiovascular Outcomes Research

NSTEMI = non–ST-segment elevation myocardial infarction

PCI = percutaneous coronary intervention

PPCI = primary percutaneous coronary intervention

STEMI = ST-segment elevation myocardial infarction

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population comprised 279,256 patients of either Caucasian (n = 259,318; 92.9%) or South Asian (n = 19,938; 7.1%) origin who underwent PCI between January 2004 and July 2011 (Fig. 1). Indications for PCI included stable angina and ACS (ST-segment elevation myocardial infarction [STEMI], non–ST-segment elevation myocardial infarction [NSTEMI], and unstable angina). Pharmacoinvasive PCI included both rescue and facilitated PCI after fibrinolysis for STEMI.

Data collection. For each PCI procedure, a total of 113 variables were collected (the current dataset is version 5.5.6 and is available at http://www.bcis.org.uk). The variables include patient demographics, indications for PCI, details of the PCI operators, technical aspects of the PCI procedure, and adverse outcomes including complications until the time of hospital discharge. Subsequent mortality was provided by independent tracking via the NHS number and the U.K. Office of National Statistics. The ethnicity recorded was that declared by the patient. South Asian includes patients of Pakistani, Indian, Bangladeshi, or Sri Lankan ethnic (not geographic) origin.

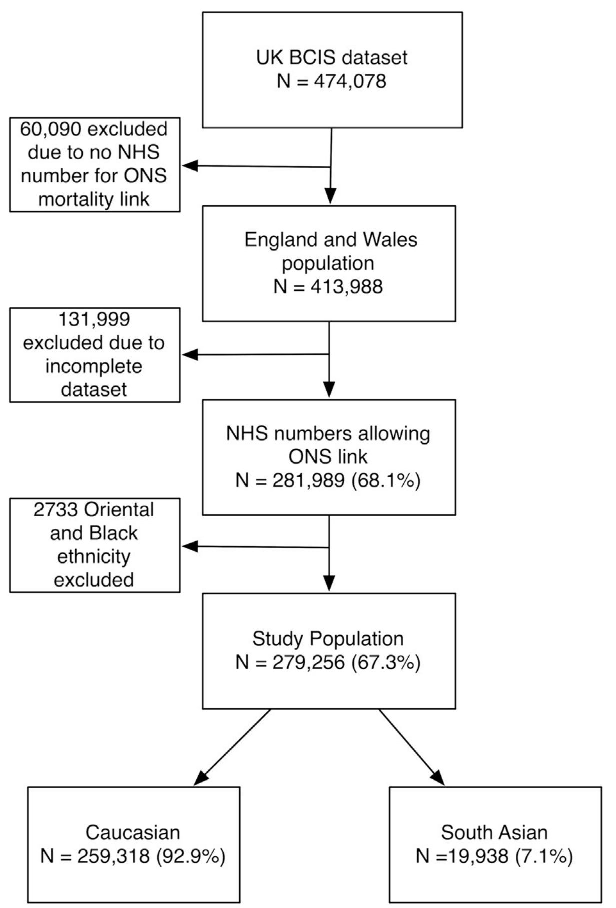

Figure 1. Flowchart of Patients Treated by Percutaneous Coronary Intervention

Patients were treated between January 2004 and July 2011. The flowchart describes patient exclusions and ethnic makeup of the study population. BCIS = British Cardiovascular Intervention Society; NHS = National Health System; ONS = Office of National Statistics.

Study outcomes. Procedural complications and in-hospital major adverse cardiac and cerebrovascular events (MACCE) were recorded and entered into the database prospectively (procedural complications at the time of the procedure and in-hospital complications until the time of discharge). In-hospital MACCE were defined as death, myocardial infarction (defined for stable and NSTEMI patients as creatine kinase level >2 times the upper limit of normal with elevated creatine kinase-myocardial band or troponin; and defined for STEMI patients as new ischemic pain with new ST-segment elevation and further elevation of enzymes, whether treated with further revascularization therapy or not), stroke, and the need for urgent target vessel revascularization (PCI or emergent coronary artery bypass grafting [CABG]). All-cause mortality data were recorded as of August 10, 2011, and obtained from the U.K. Office of National Statistics.

Ethics. The data were collected as part of a national cardiac audit exercise, and all patient identifiable information was removed before analysis. Because this analysis was performed on an anonymous data, the local ethics committee advised us that ethical approval was not required.

Statistical analysis. Clinical characteristics of South Asian and Caucasian patients were compared using the Pearson chi-square test for categorical variables. Normally distributed continuous variables were compared using the Student *t* test, and non-normally distributed continuous variables were compared using the Mann-Whitney *U* test. Normality of distribution was assessed using the Shapiro-Wilks test. We calculated Kaplan-Meier product limits for cumulative probability of reaching an endpoint and used the log-rank test for evidence of a statistically significant difference between the groups. Time was measured from the first admission for a procedure to outcome (all-cause mortality). Cox regression analysis was used to estimate hazard ratios (HRs) for the effect of ethnicity in age-adjusted and fully-adjusted models, based on covariates ($p < 0.05$) associated with the outcome. A propensity score analysis was carried out using a nonparsimonious logistic regression model comparing Caucasian and South Asian patients. Multiple variables were included in the model, including all variables with significant interactions. We then undertook a regression adjustment incorporating the propensity score into a proportional hazard model as a covariate. We used SPSS for Mac version 19.0 (SPSS, Inc., Chicago, Illinois) for all analyses.

Results

The study population comprised 279,256 patients, 19,938 (7.1%) of whom were Asian and 259,318 (92.9%) were Caucasian.

Patient demographics. South Asians undergoing PCI were significantly younger than Caucasians (Table 1). Despite this 5-year mean age difference, they had a markedly worse risk factor profile. South Asians had higher rates of diabetes (42.1% vs. 15.2%, $p < 0.0001$) and chronic kidney disease (3.9% vs. 2.0%, $p < 0.0001$) and were more likely to be current smokers. South Asians were also more likely to have undergone previous coronary revascularization (both PCI and CABG) despite their younger age at presentation.

Overall, similar proportions of South Asians and Caucasians presented with ACS, although South Asians had higher rates of STEMI and subsequent primary percutaneous coronary intervention (PPCI) but lower rates of pharmacoinvasive PCI procedures. South Asians had a greater proportion of severe impairment of left ventricular function and more frequently presented with cardiogenic shock. Caucasians had a higher incidence of previous cerebrovascular accident and peripheral vascular disease.

Anatomic and procedural characteristics. South Asians had more extensive coronary disease than Caucasians despite their younger age (Table 2). There was a higher incidence of multivessel disease in South Asians compared with Caucasians, with a higher mean number of diseased vessels. Procedural details were similar for South Asians and Caucasians, with no difference in the mean number of stents deployed per lesion (drug-eluting and bare metal stents). However, South Asians were more likely to undergo multivessel intervention, or receive a drug-eluting stent, and, when used, South Asians had a greater number of drug-eluting stents per lesion compared with Caucasians. South Asians were more likely than Caucasians to receive glycoprotein IIb/IIIa inhibitors and to have assessment with either pressure wire or intravascular ultrasound (IVUS).

PCI outcome. PROCEDURAL OUTCOME. Procedural success was similar for South Asians and Caucasians, with no significant difference between the groups for in-hospital MACCE or any of its components (stroke/ MI/ emergency bypass surgery/repeat PCI/death) (Table 3). However, there was a higher rate of coronary dissections, perforations, and side-branch occlusions in Caucasian patients.

ALL-CAUSE MORTALITY. Median patient follow-up was 2.8 years (interquartile range: 1.5 to 4.5 years). Unadjusted Kaplan-Meier estimates of all-cause mortality showed better long-term outcomes for South Asians compared with Caucasians ($p = 0.007$) (Fig. 2). However, it should be noted that the South Asian cohort was significantly younger than the Caucasian cohort. Subgroup analysis by procedural urgency showed that this difference in mortality was observed after elective procedures ($p = 0.001$) but not after PCI performed for ACS (Fig. 3).

Table 1. Baseline Characteristics According to Ethnic Group

	Caucasian (N = 260,423)	South Asian (N = 19,889)	p Value	Proportion of Data Available, % (n)
Age, yrs	64.87 ± 11.37	60.63 ± 11.79	<0.0001	100.0 (279,256)
Female	68,490 (26.5)	4,396 (22.2)	<0.0001	99.6 (278,278)
Stable angina	116,972 (45.1)	8,956 (45.3)	0.7040	99.9 (279,004)
Acute MI/ACS	142,246 (54.9)	10,830 (54.7)	0.7040	99.9 (280,024)
Previous MI	67,391 (26.5)	6,079 (31.2)	<0.0001	98.3 (274,481)
Previous CABG	21,003 (8.3)	2,414 (12.4)	<0.0001	97.4 (272,002)
Previous PCI	50,070 (19.3)	5,581 (28.2)	<0.0001	99.9 (279,004)
Hypertension	133,075 (56.0)	9,708 (53.7)	<0.0001	91.5 (255,574)
Diabetes mellitus	39,831 (15.4)	8,331 (42.1)	<0.0001	99.9 (279,256)
Diet-controlled	7,128 (2.7)	1,035 (5.2)	<0.0001	99.9 (279,256)
Medication	20,956 (8.0)	4,736 (23.8)		
Insulin	11,747 (4.5)	2,560 (12.9)		
Hypercholesterolemia	145,795 (61.7)	11,269 (62.4)	0.084	91.5 (255,574)
Current smoker	52,656 (23.5)	4,944 (28.8)	<0.0001	86.0 (240,831)
PVD	12,502 (5.2)	560 (3.0)	<0.0001	91.5 (255,484)
CKD (creatine >200), mmol/l	5,027 (2.0)	754 (3.9)	<0.0001	97.9 (273,366)
Previous CVA	9,445 (4.0)	576 (3.1)	<0.0001	91.5 (255,484)
Left ventricular function				50.0 (138,974)
Good	95918 (74.0)	6815 (72.5)	0.0015	
Moderately impaired	26,693 (20.6)	1,858 (19.8)	0.0510	
Severely impaired	6,964 (5.4)	7,26 (7.7)	<0.0001	
Cardiogenic shock	3,849 (1.6)	374 (2.1)	<0.0001	91.1 (254,491)

Values are mean ± SD or n (%), unless otherwise noted.
ACS = acute coronary syndromes; CABG = coronary artery bypass grafting; CKD = chronic kidney disease; CVA = cerebrovascular accident; MI = myocardial infarction; PCI = percutaneous coronary intervention; PVD = peripheral vascular disease.

Table 2. Procedural Characteristics According to Ethnic Group

	Caucasian (n=259,318)	South Asian (n = 19,938)	p Value	Proportion of Data Available
Indication for PCI				
ACS	142,718 (54.9%)	10,865 (54.7%)	0.649	100% (279,256)
PPCI	36,396 (14.0%)	3,047 (15.3%)	<0.0001	
NSTEMI	98,314 (36.3%)	7,449 (37.5%)	0.4145	
Pharmaco-invasive	7,670 (3.0%)	326 (1.7%)	<0.0001	
Facilitated	1,426 (0.6%)	72 (0.4%)	0.0005	
Rescue	6,244 (2.4%)	254 (1.3%)	<0.0001	
Elective	117,440 (45.1%)	9,001 (45.3%)	0.649	
Access				96% (268,619)
Femoral	162,992 (65.1%)	11,849 (61.9%)	<0.0001	
Radial	86,172 (34.4%)	7,174 (37.5%)	<0.0001	
No. of diseased vessels				79.5% (222,046)
Single-vessel	144,171 (69.6%)	10,160 (64.2%)	<0.0001	
Multi-vessel	62,637 (30.4%)	5,653 (35.9%)	<0.0001	
Mean vessels	1.11 ± 0.8	1.20 ± 0.9	<0.0001	
Single vessel intervention	207,438 (84.6%)	15,434 (83.1%)	<0.0001	94.6% (263,707)
Target vessel				
Right coronary artery	70,633 (28.8%)	4,603 (24.8%)	<0.0001	94.6% (263,707)
Left main coronary artery	2,421 (1.0%)	172 (0.9%)	0.4330	
Left anterior descending (LAD)	86,722 (35.4%)	6,735 (36.3%)	0.0164	
Left circumflex coronary artery	36,085 (14.7%)	3,033 (16.3%)	<0.0001	
Saphenous vein graft	11,577 (4.7%)	891 (4.8%)	0.6622	
Multi-vessel intervention	37,692 (15.4%)	3,143 (16.9%)	<0.0001	
IVUS	7,552 (3.3%)	688 (3.8%)	<0.0001	89.2% (248,542)
Pressure wire	14,102 (6.1%)	1,262 (7.0%)	<0.0001	89.2% (248,542)
No. of stents used	1.52 ± 1.04	1.52 ± 1.07	0.869	97.9% (273,126)
DES	151,562 (61.5%)	13,009 (68.4%)	<0.0001	95.2% (265,428)
DES used	1.03 ± 1.11	1.15 ± 1.11	<0.0001	95.2% (265,428)
Glycoprotein IIb/IIIa inhibitor	74,101 (31.5%)	6,460 (35.8%)	<0.0001	90.8% (253,439)

Values are n (%) or mean ± SD.
DES = drug-eluting stent(s); IVUS = intravascular ultrasound; NSTEMI = non–ST-segment elevation myocardial infarction; PPCI = primary percutaneous coronary intervention; other abbreviations as in Table 1.

ACS breakdown. Although there was no difference in the long-term mortality of South Asian and Caucasian patients after ACS as a whole, splitting by ACS subgroups revealed significantly higher unadjusted long-term mortality after PPCI for STEMI in Caucasians compared with South Asians (Fig. 4) but no difference in other subgroups. There was no difference after NSTEMI or pharmacoinvasive PCI. Again, it should be noted that the South Asian cohort was significantly younger than the Caucasian cohort.

Diabetes mellitus. Splitting the patients into subgroups based on diabetic status demonstrated that for both diabetic and nondiabetic patients, there was significantly higher unadjusted all-cause mortality for the Caucasian group (Fig. 5). Once again, the age difference should be noted. We also analyzed patients according to their diabetic treatment modality (diet, tablet, or insulin based). For all 3 of these categories, we found a similar higher rate of diabetes in South Asians compared with Caucasians (Table 1). There were similar higher unadjusted all-cause mortality rates for Caucasians in each of these diabetic subgroups (data not shown) as for the diabetic population as a whole.

Cox analysis. The age-adjusted Cox analysis showed an increase in the hazard of death for South Asians compared with Caucasians (HR: 1.24; 95% confidence interval [CI]: 1.18 to 1.30), but the difference was lost with multiple adjustment (HR: 0.99; 95% CI: 0.94 to 1.05). All covariates in this model and their HRs are shown in Figure 6.

In the subgroup of patients in whom left ventricular systolic function was documented on discharge (138,974, 50.0%), there remained no association between ethnicity and mortality, even after correcting for left ventricular systolic function (adjusted HR: 1.03; 95% CI: 0.93 to 1.08). Additionally, after regression adjustment incorporating the propensity score into a proportional hazard model as a covariate (calculated from age, ACS presentation, sex, diabetes, hypertension, hypercholesterolemia, previous CABG,

Table 3. In-Hospital Outcomes and Complications After PCI According to Ethnic Group

	Caucasian (n = 259,318)	South Asian (n = 19,938)	p Value	Proportion of Data Available, % (n)
In-hospital				
MACCE	5,422 (2.2)	451 (2.4)	0.0709	94.7 (263,883)
Death	2,885 (1.2)	239 (1.3)	0.2184	
Q-wave MI	1,307 (0.5)	110 (0.6)	0.3353	
Reintervention PCI	723 (0.3)	67 (0.4)	0.1399	
CVA	263 (0.1)	16 (0.1)	0.4499	
Emergency CABG	244 (0.1)	19 (0.1)	0.9798	
Coronary dissection/perforation	5,857 (2.5)	297 (1.6)	<0.0001	90.1 (250,949)
Aortic dissection	133 (0.1)	10 (0.1)	0.9572	
Side branch occlusion	1,770 (0.8)	98 (0.5)	0.0011	
No/slow flow	2,618 (1.1)	176 (1.0)	0.0619	
Heart block	473 (0.2)	33 (0.2)	0.5982	
DC cardioversion	727 (0.3)	44 (0.2)	0.1182	
Arterial complications	1,312 (0.5)	78 (0.4)	0.3353	

Values are n (%), unless otherwise noted.
DC = direct current; MACCE = major adverse cardiac and cerebrovascular events; other abbreviations as in Table 1.

previous PCI, previous myocardial infarction, previous cerebrovascular accident, peripheral vascular disease, access site, procedural success, chronic total occlusion, multivessel disease, chronic kidney disease, and glycoprotein IIb/IIIA inhibitor use), there was no difference in mortality between South Asians and Caucasians (HR: 0.99; 95% CI: 0.93 to 1.05).

Discussion

This study, using data from a large national PCI registry of consecutive cases in England and Wales over a 7-year period, is the largest observational study to date comparing the outcomes of South Asians and Caucasians after PCI. We describe a cohort of South Asian patients who are fundamentally different from their Caucasian counterparts. Despite being on average 5 years younger, the South Asians had more extensive disease, more complex cardiac histories, and an alarming rate of diabetes mellitus (42% vs. 15% for Caucasians). Although it is often assumed that South Asian patients will have a higher mortality than Caucasians after PCI, we have found that the unadjusted long-term mortality for South Asians was actually lower than that in Caucasians, mainly as a result of their much younger age at presentation. After correction for age alone, mortality was higher in the South Asians, but after adjustment for the other significant differences between the 2 groups (in particular, the >3-fold greater prevalence of diabetes), we observed no overall difference in the long-term mortality of South Asians versus Caucasians. This is consistent with other contemporary studies examining the effect of ethnicity on outcomes after PCI (11,13,15).

Despite a younger age, this cohort of South Asians had a higher prevalence of both diabetes and chronic kidney disease and a higher rate of smoking, all of which are strongly associated with premature vascular disease. This is the likely explanation why South Asians present with such extensive coronary disease and at a younger age than Caucasians (7). Conversely, South Asians were less likely to have hypertension, previous stroke, or peripheral vascular disease. Immigration is a dynamic process, and with the increase in rates of obesity globally (18), it is likely that the risk factor profile of patients will continue to change with time. This would be an extremely important area for further study in view of our findings primarily related to the

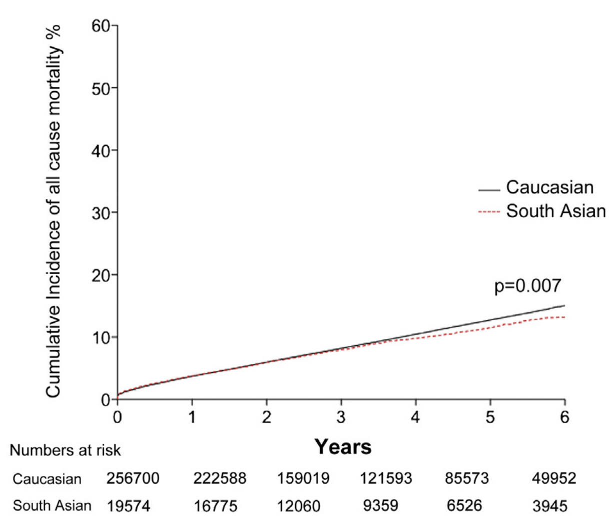

Figure 2. Kaplan-Meier Curves Showing Cumulative Probability of All-Cause Mortality

Kaplan-Meier curves showing higher unadjusted cumulative probability of all-cause mortality after PCI in Caucasians compared to South Asians.

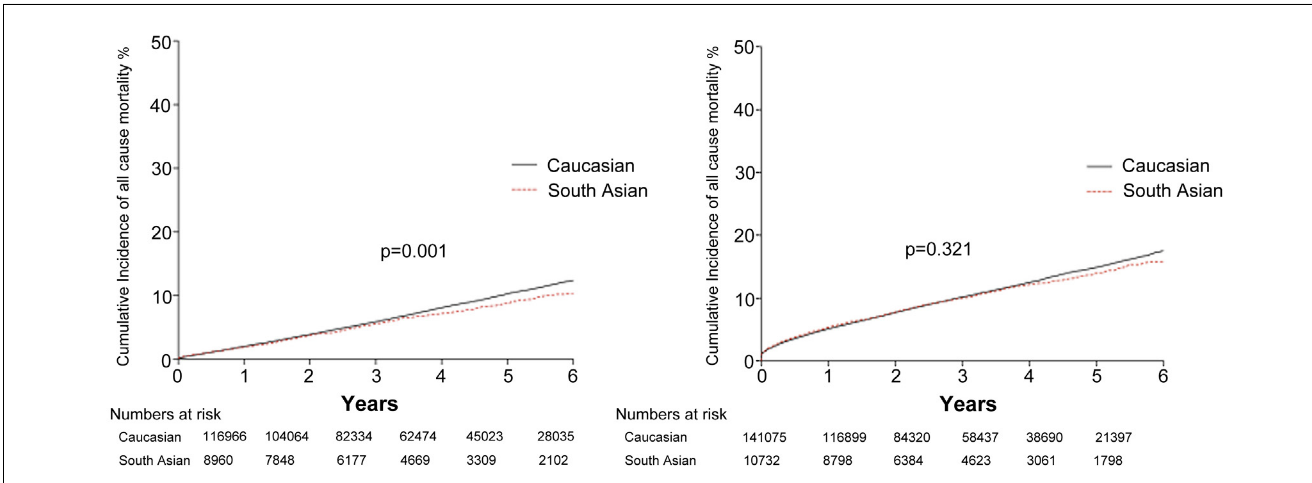

Figure 3. Kaplan-Meier Curves Showing Cumulative Incidence of All-Cause Mortality

(A) Kaplan-Meier curves showing higher cumulative incidence of unadjusted all-cause mortality after elective percutaneous coronary intervention (PCI) for Caucasian compared to South Asian patients. **(B)** Kpaln-Meier curves showing similar cumulative incidence of all-cause mortality after PCI for acute coronary syndromes for Caucasian and South Asian patients (unadjusted data).

very high rates of diabetes in our South Asian population. Additionally, the degree to which diabetes in young South Asians represents a fixed genetic predisposition versus a clinically modifiable or preventable risk factor also deserves further study.

In this cohort, STEMI was a more common presentation among South Asians, and consequently South Asians were more likely to undergo PPCI than Caucasians. As with previous research, the largest unadjusted mortality difference between South Asians and Caucasians was after PPCI, with Caucasians faring worse (12). This difference is primarily explained by the age difference between the 2 groups. South Asians presenting with STEMI were on average 6 years younger (data not shown) than their Caucasian counterparts. However, despite the younger age of the South Asians, it is again worth emphasizing the significant difference in their risk factor profile compared with Caucasians. For example, 42% of South Asians presenting with STEMI were diabetic compared with 15% of Caucasians. After correcting for these significant differences in age and comorbidity, there was no longer a significant difference in outcomes between South Asians and Caucasians. This analysis suggests that the observed differences between these 2 populations can be explained purely on the basis of conventional risk factors for coronary disease and that ethnicity itself does not appear to be an independent predictor of outcome. Our data do not suggest, from a PCI perspective, that there is no difference between the 2 populations; rather, we imply that the differences in outcome that we describe appear to be explained by conventional risk factors. Essentially, being South Asian implies being much more likely to have major risk factors, particularly diabetes, and carrying the adverse prognostic effects of this.

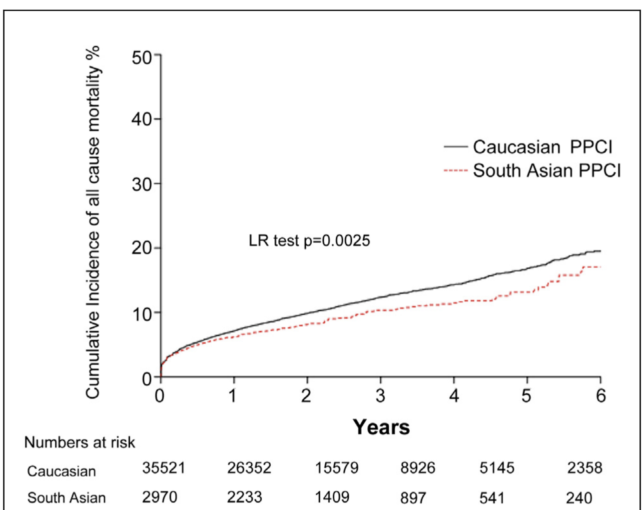

Figure 4. Kaplan-Meier Curves Showing Cumulative Incidence of All-Cause Mortality After PPCI

The curves show a higher incidence of cumulative unadjusted all-cause mortality after PPCI for Caucasian compared to South Asian patients. LR = log-rank; PPCI = primary percutaneous coronary intervention.

Although our data suggest that this difference in outcome can be explained by these conventional risk factors, other variables may also be contributing to the effect. Socioeconomic status can affect the outcome of numerous medical conditions (19). However, recent work from the United Kingdom has suggested that low socioeconomic status does not disproportionately affect outcome of South Asians (13).

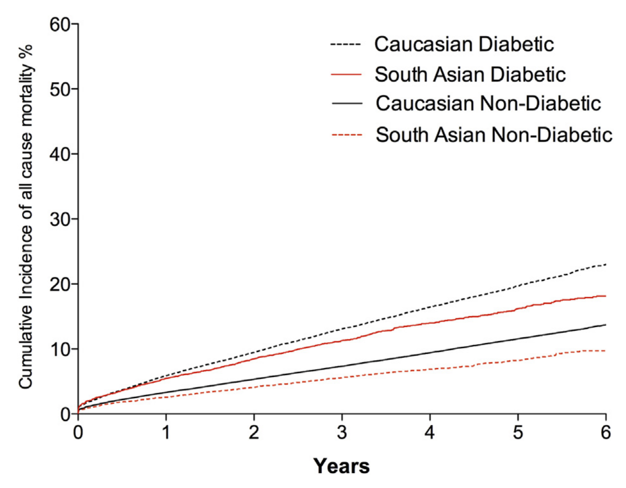

Figure 5. Kaplan-Meier Curves Showing Cumulative Incidence of All-Cause Mortality After PCI for Patients With Diabetes Mellitus

Kaplan-Meier curves showing a higher incidence of cumulative all-cause mortality after PCI for diabetic Caucasian and South Asian patients compared to nondiabetic ethnicity matched groups ($p<0.0001$) (unadjusted data). PCI = percutaneous coronary intervention.

Likewise, secondary prevention prescription and compliance may be different between our 2 populations. However, data from a similar population in the United Kingdom actually suggests that secondary prevention prescription may actually be better in South Asians (13), and this was also shown in a Canadian study (20). We did not investigate the impact of compliance with secondary prevention in our population on outcome. However, there are some data that suggest that the compliance of some aspects of secondary prevention may be lower in South Asian patients, and conceivably this could have influenced the results.

A contemporary North American study reported that South Asians have improved survival after AMI compared with Caucasians (12). It is difficult to compare our results with those of this study because the U.K. South Asian population comprises much high proportions of Pakistani and Bangladeshi South Asians than the North American South Asian population, the majority of whom originate from further south on the Indian subcontinent (21,22). Both Pakistani and Bangladeshi South Asians appear to have a higher mortality from cardiovascular disease than Indian South Asians (3).

A recent meta-analysis and national cohort study has also come to conclusions similar to ours regarding the association of outcome with South Asian status (13). Although South Asian ethnicity is associated with a higher incidence of CAD, there appears to be a lower mortality once the CAD presents compared with Caucasian ACS patients. These data are in accord with our findings in an unselected PCI cohort including elective as well as ACS patients.

It is possible that South Asians have different access to healthcare pathways, and this may influence their outcome. However, in the United Kingdom, ethnicity is not associated with inequality of access to chest pain assessment services (23), and national registry data provide no evidence of undertreatment of South Asians with ACS (24,25). We did

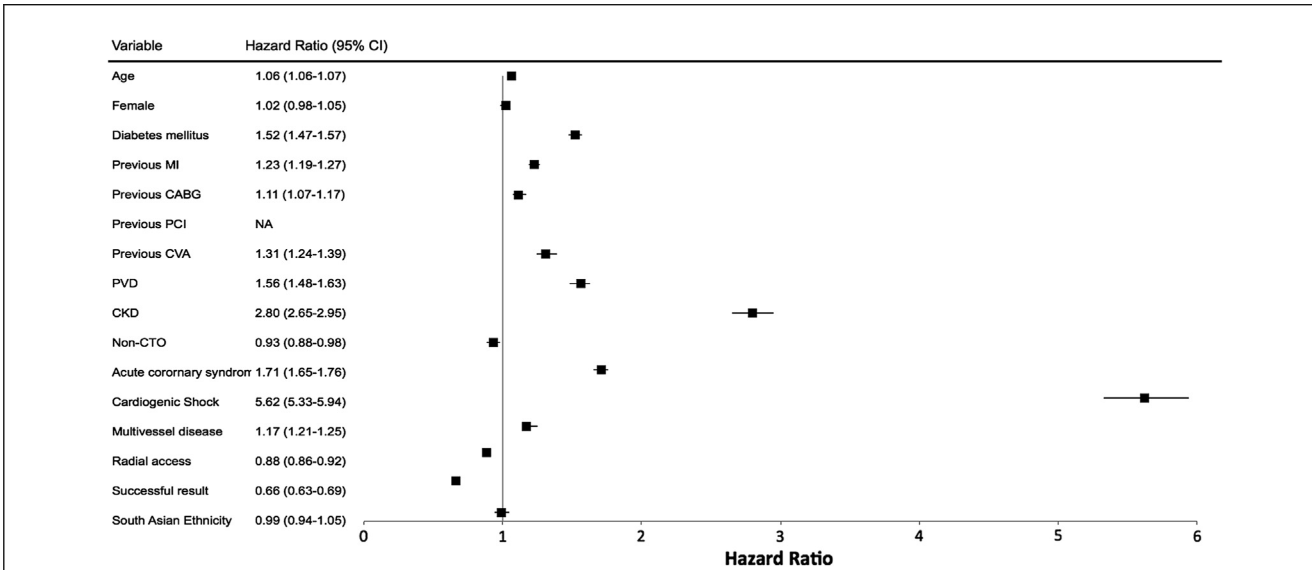

Figure 6. Hazard Ratios for All-Cause Mortality

Multivariate hazard ratios of the Cox analysis for all cause mortality after percutaneous coronary intervention (PCI) with 95% confidence intervals (CIs) showing no association between ethnicity and all cause mortality. CABG = coronary artery bypass grafting; CKD = chronic kidney disease; CTO = chronic total occlusion; CVA = cerebrovascular accident; MI = myocardial infarction; NA = not applicable; PVD = peripheral vascular disease.

observe higher rates of pharmacoinvasive PCI in the Caucasian group, implying that South Asians may be more likely to receive PPCI for STEMI as the initial management strategy. Although we did not explore this, this difference may be related to the geographic distance of patients to heart attack centers. In the United Kingdom, the majority of South Asians reside in urban areas and therefore are closer to regional heart attack centers (26). This may give them better access to PPCI. Our study focused on PCI patients, and hence we do not have data on patients treated primarily by fibrinolysis for STEMI. However, U.K. studies (from the fibrinolysis era) suggested that access to fibrinolysis may be better for South Asian patients than Caucasians, supporting the suggestion that South Asians had greater access to PPCI in the PPCI era. Additionally, our analysis of patients treated with pharmacoinvasive approaches had similar outcomes for both ethnic groups.

We also know that South Asians in the United Kingdom have similar survival rates after cardiac arrest (27), suggesting that there is unlikely to be a difference in prehospital survival, which could conceivably bias results. Our study confirms that with contemporary treatment equitably applied across ethnic groups, case fatality rates for patients with established CAD undergoing PCI are no higher for South Asians than for Caucasians. We can therefore speculate that the presentation of CAD at a younger age in South Asians may enable the effective implementation of preventive measures. An emphasis on education reinforcing that South Asians are more likely to develop diabetes and premature CAD along with specific drug, dietary, and lifestyle interventions are important steps in improving outcomes (28,29).

The strengths of this dataset are that it includes a comprehensive collection of all PCI procedures performed in England and Wales. Therefore, it includes treatment of all patients, low- and high-risk alike, and contains a large number of procedures. Most importantly for this study, it includes a high number of South Asian patients. Mortality tracking in England and Wales is particularly robust based on official U.K. Office of National statistics data. The univariate, multivariate, and propensity analyses highlight the quality of the data with well-recognized predictors of mortality associated with adverse outcomes in our dataset. The univariate, multivariate, and propensity analysis highlights the quality of the data with well-recognized predictors of mortality associated with adverse outcome in our data set with event rates similar to other large published cohorts of PCI patients (30).

Study limitations. Despite these strengths, there are a number of important limitations common to observational studies of this type. The BCIS data collection shares the weaknesses of other national registries as there is always a balance between the size of the dataset and the willingness and ability to collect it accurately. Although 32% of patients were recorded as unknown ethnicity and hence not included in the analysis, we found no difference in outcome compared with the study group (data not shown). National datasets rely on self-reporting of adverse events, and there is no external validation of these results, although the mortality data are robust as they are from the U.K. Office of National Statistics. Although the assessment of mortality is very strong and particularly appropriate for interventions aimed at reducing mortality (such as PCI for ACS), some other aspects of late patient outcome are not assessed, such as recurrent myocardial infarction, need for later additional revascularization, and follow-up data on quality of life and angina status are not recorded. Unfortunately, we only have all-cause mortality as an endpoint, and therefore we cannot analyze cardiac death specifically. We cannot account for the effects of residual confounding or selection bias caused by exclusion of 32% of patients with incomplete datasets. Categorizing patients as South Asian may obscure important outcome differences between the different constituent ethnic subgroups (2). We accept that there is likely to be considerable heterogeneity within the South Asian population. Although this may not be a major factor affecting outcome after myocardial infarction in the United Kingdom, the effect of different subgroups of South Asians would require further study in the PCI population (13). As this was an observational study, there may also be confounding factors that we have been unable to control for. This may include adherence to evidence-based therapies (e.g., medication), which has been shown to be associated with outcome, although prescription of secondary prevention may actually be slightly higher in South Asians (13).

Conclusions

In the largest published contemporary cohort of patients undergoing PCI, we describe a South Asian population that, although being a mean of 5 years younger than Caucasian controls, has a 42% rate of diabetes and more extensive coronary disease. As expected, the younger South Asian cohort has a lower unadjusted mortality. Age-adjusted data show a higher mortality after PCI, but there was no difference between South Asians and Caucasians in long-term case fatality rates after correction for baseline characteristics. This adds further weight to the emerging consensus that the excess coronary mortality for people of South Asian origin largely reflects their propensity for developing premature diabetes. Corrected case fatality rates are not different from those of Caucasian patients.

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